Office of
Transportation Technologies

OTT and small entrepreneurial company team up

A breakthrough lightweight materials manufacturing process is optimized

Reducing the weight of a vehicle provides a corresponding fuel savings that can, when multiplied by the millions of cars on the road, add up to a significant reduction in America's dependence on foreign oil, as well as a substantial reduction in polluting automotive emissions such as carbon dioxide and NO_x. Over the past few years, innovative American auto manufacturers have begun replacing many traditional steel and iron components—especially the heaviest structural components—with lighter aluminum parts, reducing the relative weight by up to 50 percent or more, and increasing the overall fuel economy of the vehicles.

Unfortunately, economic considerations currently limit manufacturers' ability to substantially lower vehicle weight. In order to achieve the strength required for structural automotive parts, aluminum parts need to be forged, a manufacturing process that is time- and labor-intensive. Although material cost is often lower because of the lower volume of metal required, the cost of forging the aluminum to achieve the high standards required by auto manufacturers can make widespread steel and iron replacement cost-prohibitive, and is an impediment to achieving significant weight reductions.

An innovative process that lowers the cost of aluminum parts. By early 1995, engineers at a small company in Cleveland, Ohio—Thompson Aluminum Casting (TAC)—had preliminary indications that an innovative solution that could potentially give automotive engineers a cost-effective alternative to aluminum forging with a variant of the squeeze casting process. This process could avoid microcracks and impart properties equal to that of a forged part. Known as metal compression forming, the process calls for even pressure across the full profile of the part, allowing better control over the solidification process and the part's ultimate microstructure. TAC's innovations included the development of interfacing technologies such as programmable controllers, sensors and hydraulic controls which could establish metal compression forming as a reliable, repeatable technology practical for use in the high volume world of auto manufacturing.

Strong interest from one of the Big Three—and an "impossible" challenge. News of TAC's innovation reached the Delphi Chassis Division of General Motors, who already had an innovative program in place to manufacture motor mounts out of forged aluminum instead of the traditional cast iron, and get these large structural components into 1998 cars. On November 30, 1995, GM offered TAC a challenge—deliver prototype aluminum motor mounts manufactured with metal compression forming by April 1, 1996, and the prototype parts would be tested side-by-side with Delphi's forged aluminum prototypes for possible inclusion in the 1998 vehicles.

OTT's Office of Transportation Materials and TAC in a "mini-Manhattan project". "This was an exciting, and nearly unprecedented challenge—development of a new regular production automotive part usually takes upwards of three years, significantly longer than the four-month window GM had established," explained TAC President Bob Purgert. "Still, the opportunity was unprecedented also—there was no way to know when the chance to get our parts on a regular production automobile so quickly would come again—or if at all."

Fortunately, several months earlier, TAC had entered a Cooperative Research and Development Agreement (CRADA) with OTT and the DOE Oak Ridge National Laboratory (ORNL), with the goal of optimizing the metal compression forming process and developing actual parts.

"GM said to us 'here's your chance to do this not just for the sake of knowledge, but for a real-world commercial application,' "said Purgert. "Our Program Manager at

OTT looked at the extent of the challenge and the time frame and dubbed it a 'mini-Manhattan project'—and within 24 hours of the meeting with GM, he said 'let's go for it.'"

The Department of Energy's (DOE) computer power—and credibility—make the difference for a small company. Purgert notes that it was the credibility provided by OTT's expressed interest in the TAC process that helped them get the original audience with GM, elevating them above many others who were calling upon the auto manufacturers. But, as the four-month challenge to optimize their process began, OTT brought more quantifiable resources to bear.

As part of the CRADA, the partners tapped into the massively parallel computer modeling capabilities at ORNL, allowing them to perform millions of "what if" calculations on dozens of variables including heat flow control and die cavity dimensions. Runs which would have taken hundreds of hours on a traditional mainframe where achieved in just a few hours, or even minutes.

"Access to this level of modeling capability is out of reach to all but the largest organizations," said Purgert. "Without DOE's computer power—and the expertise to use it effectively—there is no way this challenge could have been met in anywhere near the time frame allowed."

Working hand-in-hand at ORNL and TAC, the CRADA partners worked to optimize the process. The first cast they made showed some minor defects. Going back to computer modeling, new calculations suggested that they shave 8/10 mil (about .0008 inch) off the die. They did—and the results were spectacular.

Parts delivered, tested—and commercialized. The CRADA team met the timing challenge, and Delphi tested the TAC/OTT aluminum parts in a grueling process that simulated stresses some 300 percent greater than those likely to be encountered in service. Their findings: that the TAC process produces a lightweight aluminum part that is more consistent and resistent to cracking than does traditional casting—at a cost 40 percent less than forging. They followed up their findings with the announcement that the TAC/OTT parts would be included on the 1998 Cadillac STS 5, and entered an order for 400,000 parts in 1997 and 750,000 in 1998.

A process driving the future of lighter weight, more fuel efficient transportation. TAC is continuing to improve the forming process, and the potential exists for future collaborations with OTT. Work is also under consideration to test the process with materials that would allow the creation of parts that provide high strength at even lighter weights, such as metal matrix composites and magnesium, the latter offering the potential to create parts 40 percent lighter than aluminum.

The TAC process provides a cost-effective method of manufacturing quality lighter weight parts, giving automotive design engineers a wider range of possibilities to consider. With a further optimized process and its use with increasing numbers of light- weight materials, it is expected that these fuel-saving materials will show up in more and more applications, leading to a potentially significant decrease in demand for foreign oil. Purgert is pleased with the success of the CRADA arrangement with OTT, and believes that the opportunity exists for further win-win partnerships for TAC as well as other small entrepreneurial companies with big ideas and smaller pocketbooks.

"People just don't realize the incredible resources that are available, and with the end of the Cold War, many of these resources can be effectively channeled into efforts that can bolster our economy," he said. "DOE and their National Laboratory resources can be extremely helpful to companies seeking to develop and prove-out exciting new technologies."

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